UL 60079-29-1

STANDARD FOR SAFETY

Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases

UL Standard for Safety for Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases, UL 60079-29-1

Second Edition, Dated May 31, 2019

Summary of Topics

Adoption of IEC 60079-29-1, Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases (second edition, issued by IEC July 2016) as a new IEC-based UL standard, UL 60079-29-1 with US Differences.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL and FM are committed to updating this harmonized standard jointly.

The new requirements are substantially in accordance with Proposal(s) on this subject dated November 9, 2018 and February 15, 2019.

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FM Approvals LLC
ANSI/FM 60079-29-1-2019
Second Edition

Underwriters Laboratories, LLC
UL 60079-29-1
Second Edition

Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases

May 31, 2019

ANSI/UL 60079-29-1-2019

Commitment for Amendments

This standard is issued jointly by FM Approvals LLC and Underwriters Laboratories Incorporated (UL). Comments or proposals for revisions on any part of the standard may be submitted to FM Approvals or UL at any time. FM and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

The most recent designation of ANSI/FM 60079-29-1 as an American National Standard (ANSI) occurred on May 31, 2019.

This ANSI/UL Standard for Safety consists of the Second Edition. The most recent designation of ANSI/UL 60079-29-1 as an American National Standard (ANSI) occurred on May 31, 2019. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards. Any other portions of this ANSI/UL standard that were not processed in accordance with ANSI/UL requirements are noted at the beginning of the impacted sections.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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PREFACE

This is the harmonized FM and UL standard for Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases. It is the second edition of FM 60079-29-1 and the second edition of UL 60079-29-1.

This harmonized standard is based on IEC Publication 60079-29-1: second edition, Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases issued July 2016. IEC publication 60079-29-1 is copyrighted by the IEC.

Efforts have been made to synchronize the UL edition number with that of the corresponding IEC standard with which this standard is harmonized. As a result, one or more UL edition numbers have been skipped to match that of the IEC edition number.

At the time of this publication, IEC 60079-29-1, Edition 2 is available from IEC in English only.

This harmonized standard was prepared by FM Approvals LLC (FM) and Underwriters Laboratories Inc. (UL).

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of Harmonization

This standard adopts the IEC text with national differences.

This standard is published as an identical standard for FM and UL.

An identical standard is a standard that is exactly the same in technical content except for national differences resulting from conflicts in codes and governmental regulations. Presentation is word for word except for editorial changes.

All national differences from the IEC text are included in the FM and UL versions of the standard. While the technical content is the same in each organization's version, the format and presentation may differ.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

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The following people served as members of STP 9200 and participated in the review of this standard:

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National Differences

National Differences from the text of International Electrotechnical Commission (IEC) Publication 60079-29-1, Explosive Atmospheres – Part 29-1: Gas Detectors – Performance Requirements of Detectors for Flammable Gases, copyright 2016, are indicated by notations (differences) and are presented in bold text.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

DR – These are National Differences based on the **national regulatory requirements**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add – An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Deletion / Delete – A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

Modification / Modify – A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

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FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and nongovernmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

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8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60079-29-1 has been prepared by IEC technical committee 31: Equipment for explosive atmospheres.

This second edition of IEC 60079-29-1 cancels and replaces the first edition of IEC 60079-29-1:2007 series and constitutes a technical revision.

Significant technical changes between IEC 60079-29-1, Edition 1 (2007), and IEC 60079-29-1, Edition 2 (2016), is as listed below:

Significant changes with respect to IEC 60079-29-1:2007

Changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Measuring range up to 20 %LEL (Modified requirements)	All		X	
Definitions (Additional clarifications)	3	X		
Manufacturer's claims (special applications requirements)	4.1.1	X		
General construction (Malfunction effects on safety related function)	4.2.1			C1
General indicating devices (portable equipment with visual and audible indication)	4.2.2.1			C2
Suppression of indication and measured values below zero (functional limits)	4.2.2.5			C3
Fault signals (Fault indication below minimum voltage limit, sensor disconnection and zero drift condition)	4.2.4			C4
Adjustments (Zero and sensitivity adjustments)	4.2.5			C5
Marking (Portable equipment protective case)	4.3		X	
Instruction Manual (Additions and clarifications)	4.4			C6
Samples and sequence of tests (Optical filter special sensitivity limits, and modification considerations)	5.2.2		X	
Preparation of equipment before testing (separate gas detection control units)	5.2.3	X		
Test gas (methane, and propane or butane for general purpose gas detector)	5.3.2			C7
General test methods (selectable range and wiring worst case conditions)	5.4.1		X	
Calibration curve (fixed volume fractions)	5.4.3.2			C8
Response to different gases (semiconductor and catalytic high gas concentration exposure)	5.4.3.3			C9
Stability (duration of test method)	5.4.4		X	
Alarm set point(s) (alarm set point test method)	5.4.5	X		
Temperature (portable) (temperature range and stabilization period)	5.4.6			C10
Temperature (all other equipment) (temperature range and stabilization period)	5.4.6		X	
Pressure (tolerance on pressure measurement)	5.4.7	X		
Humidity of test gas (test method clarification)	5.4.8	X		
Air velocity (test method clarification)	5.4.9	X		
Flow rate for aspirated equipment (test method clarification)	5.4.10	X		
Vibration	5.4.12	X		

Changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
(test method clarification)				
Drop test for portable and transportable equipment (Automatic re-starting or shut-down requirement clarification)	5.4.13	X		
Warm-up time (user prompt requirement)	5.4.14			C11
High gas concentration operation above the measuring range (test method and requirement clarification)	5.4.16	X		
Battery capacity (test method clarification)	5.4.17	X		
Power supply variation (minimum supply voltage fault limit)	5.4.18			C12
Poisons (applicable only to Group I apparatus with catalytic or semiconductor sensors) (test method clarification)	5.4.20.2	X		
Electromagnetic compatibility (test methods and requirements)	5.4.21			C13
Field calibration kit (test method clarification)	5.4.22	X		
Software function (supporting documentation)	5.4.23		X	
Determination of time of response (test method clarification)	Annex B		X	

NOTE 1 The technical changes referred to include the significance of technical changes in the revised IEC Standard, but they do not form an exhaustive list of all modifications from the previous version. More guidance may be found by referring to the Redline Version of the standard.

Explanations:

A) Definitions

Minor and editorial changes

Clarification decrease of technical requirements minor technical change editorial corrections.

These are changes which modify requirements in an editorial or a minor technical way. They include changes of the wording to clarify technical requirements without any technical change, or a reduction in level of existing requirement.

Extension

Addition of technical options

These are changes which add new or modify existing technical requirements, in a way that new options are given, but without increasing requirements for equipment that was fully compliant with the previous standard. Therefore, these will not have to be considered for products in conformity with the preceding edition.

Major technical changes

Addition of technical requirements increase of technical requirements.

These are changes to technical requirements (addition, increase of the level or removal) made in a way that a product conforming to the preceding edition will not always be able to fulfil the requirements given in the later edition. These changes have to be considered for products conforming to the preceding edition. For these changes additional information is provided in B) below.

NOTE 2 These changes represent current technological knowledge. However, these changes should not normally have an influence on equipment already placed on the market.

B) Information about the background of 'Major technical changes'

C1 Addition of malfunction effects not adversely affecting the safety related function (4.2.1).

C2 Addition of visual and audible indication for portable equipment (4.2.2.1).

C3 Addition of functional limits for suppression of indication and for measured values below zero (4.2.2.5).

C4 Addition of requirements for fault indication below minimum voltage limit, sensor disconnection and zero drift condition (4.2.4).

C5 Addition of requirements for zero and sensitivity adjustments (4.2.5).

C6 Addition and clarification requirements for inclusion within the instruction manual (4.4).

C7 Addition of methane and propane or butane as required test gases for general purpose gas detector (5.3.2).

C8 Specification of fixed volume fractions which are expressed as a percentage of the measuring range (5.4.3.2).

C9 Addition of requirement for semiconductor and catalytic sensors to be exposed to high gas concentration on response to different gases (5.4.3.3).

C10 Addition of temperature range and stabilization period (5.4.6).

C11 Addition of requirement where equipment prompts the user (5.4.14).

C12 Addition of requirement for output functionality above the minimum supply voltage fault limit (5.4.18).

C13 Addition of test methods and requirements for electromagnetic compatibility tests (5.4.21).

The text of this standard is based on the following documents:

FDIS	Report on voting
31/1257/FDIS	31/1266/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60079 series, under the general title *Explosive atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore. iec. ch" in the data related to the specific publication. At this date, the publication will be

• reconfirmed,

• withdrawn,

• replaced by a revised edition, or

• amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

This part of ~~IEC~~UL 60079-29 specifies general requirements for construction, testing and performance, and describes the test methods that apply to portable, transportable and fixed equipment for the detection and measurement of flammable gas or vapour concentrations with air.

Guidance for the selection, installation, use and maintenance of gas detecting equipment is set out in IEC 60079-29-2: *Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*.

Guidance for ~~functional safety of fixed gas detection systems~~gas detection as a method of protection is set out in ANSI/ISA-TR12.13.03 Guide for Combustible Gas Detection as a Method of Protection ~~IEC 60079-29-3: *Explosive atmospheres – Part 29-3: Gas detectors – Guidance on functional safety of fixed gas detection systems*~~.

General requirements for construction, testing and performance of open path detectors for flammable gases are set out in IEC 60079-29-4: *Explosive atmospheres – Part 29-4: Gas detectors – Performance requirements of open path detectors for flammable gases*.

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EXPLOSIVE ATMOSPHERES – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases

1 Scope

1DV DR *Modification of Clause 1 to replace with the following:*

This ~~part of IEC 60079-29~~ standard specifies general requirements for construction, testing and performance, and describes the test methods that apply to portable, transportable and fixed equipment for the detection and measurement of flammable gas or vapour concentrations with air. The equipment, or parts thereof, is intended for use in explosive atmospheres and in mines susceptible to firedamp.

This ~~part of IEC 60079-29~~ standard is applicable to flammable gas detection equipment with a measuring range up to any volume fraction as declared by the manufacturer, and which is intended to provide an indication, alarm or other output function; the purpose of which is to indicate a potential explosion hazard and in some cases, to initiate automatic or manual protective action(s).

For the purposes of this ~~part of IEC 60079-29~~ standard, the term "indicating up to a volume fraction of X % or X %LFL" includes equipment with an upper limit of the measuring range equal to or less than X % or X %LFL.

This ~~part of IEC 60079-29~~ standard is applicable to equipment, including the integral sampling systems of aspirated equipment, intended to be used for commercial, industrial and non-residential safety applications.

This ~~part of IEC 60079-29~~ standard does not apply to external sampling systems, or to equipment of laboratory or scientific type, or to equipment used only for process monitoring and/or control purposes. It also does not apply to open path (line of sight) detectors which are within the scope of IEC 60079-29-4. Only equipment with very short optical paths intended for use where the concentration is uniform over the optical path are within the scope of this standard.

For equipment used for sensing the presence of multiple gases, this ~~part of IEC 60079-29~~ standard applies only to the detection of flammable gas or vapour.

This ~~part of IEC 60079-29~~ standard supplements and modifies the general requirements of IEC 60079-0. Where a requirement of this standard conflicts with a requirement of IEC 60079-0, the requirement of ~~IEC 60079-29-1~~ this standard takes precedence.

NOTE 1 IEC 60079-29-1 is intended to provide for the supply of equipment giving a level of safety and performance suitable for general purpose applications. However, for specific applications, a prospective purchaser (or an appropriate authority) can additionally require the equipment to be submitted to particular tests or approval. For example, Group I equipment (i.e. equipment to be used in mines susceptible to firedamp) might not be permitted to be used without the additional, prior approval of the relevant authority in mines under its jurisdiction. Such particular tests/approval are to be regarded as additional to and separate from the provisions of the standards referred to above and do not preclude certification to or compliance with these standards.

NOTE 2 All equipment calibrated on specific gases or vapours can not be expected to correctly indicate on other gases or vapours.

For the purposes of this standard, the terms "lower flammable limit (LFL)" and "lower explosive limit (LEL)" are deemed to be synonymous, and likewise the terms "upper flammable limit (UFL)" and "upper explosive limit (UEL)" are deemed to be synonymous. For ease of reference, the two abbreviations LFL and UFL may be used hereinafter to denote these two sets of terms. It should be recognized that particular authorities having jurisdiction may have overriding requirements that dictate the use of one of these sets of terms and not the other.

NOTE 3 Indication of concentration in %(v/v) or vol ppm can also be available for equipment which measures up to 100 %LFL or 20 %LFL. In that case, units of measurement might need to be selected in agreement with the manufacturer when verifying the performance requirements of Annex A.

Where references are made to other IEC 60079 standards, the reference requirements found in these standards shall apply as modified by any applicable U.S. National Differences.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2DV DR *Modification of Clause 2 to replace with the following:*

ANSI/NFPA 497, *Recommended Practice for Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installation in Chemical Process Areas*

IEC 60050-426, *International Electrotechnical Vocabulary – Part 426: Equipment for explosive atmospheres*

~~**IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements***~~

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

~~**IEC 60079-20-1, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapour classification – Test methods and data***~~

IEC 60529, *Degrees of Protection Provided by Enclosures (IP)*

IEC 61326-1:2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61508-3, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*

UL 60079-0, *Explosive Atmospheres – Part 0: Equipment – General Requirements*

UL 60079-29-2, *Explosive atmospheres – Part 29-2: Gas detectors – selection, installation, use and maintenance of detectors for flammable gases and oxygen*

3 Definitions

For the purposes of this document, the terms and definitions given in IEC 60079-0 and the following apply. Additional definitions applicable to explosive atmospheres can be found in IEC 60050-426.

3.1 gas properties

3.1.1 ambient air
normal atmosphere surrounding the equipment

3.1.2 clean air
air that is free of gases or vapours which the sensor is sensitive to or which influence the performance of the sensor

3.1.3 flammable gas
gas or vapour which, when mixed with air in a certain proportion, will form an explosive atmosphere

Note 1 to entry: For the purposes of this part of IEC 60079-29, the term "flammable gas" includes flammable vapours.

Note 2 to entry: For the purposes of this part of IEC 60079-29, the terms "combustible gas" and "flammable gas" are equivalent.

3.1.4 lower flammable limit
LFL
concentration of flammable gas or vapour in air, below which an explosive gas atmosphere does not form

Note 1 to entry: This is also known as lower explosive limit (LEL).

Note 2 to entry: The concentration may be expressed as either a volume fraction or a mass per unit volume.

3.1.5 poisons
< for sensing elements > substances that lead to temporary or permanent change of performance, particularly loss of sensitivity of the sensing element

3.1.6 upper flammable limit
UFL
concentration of of flammable gas or vapour in air, above which an explosive gas atmosphere does not form

Note 1 to entry: This is also known as upper explosive limit (UEL).

Note 2 to entry: The concentration may be expressed as either a volume fraction or a mass per unit volume.

3.1.7 volume fraction
v/v
quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing, all volumes referring to the pressure and the temperature of the gas mixture

Note 1 to entry: The volume fraction and volume concentration take the same value if, at the same state conditions, the sum of the component volumes before mixing and the volume of the mixture are equal. However, because the mixing of two or more gases at the same state conditions is usually accompanied by a slight contraction or, less frequently, a slight expansion, this is not generally the case.

3.1.8 zero gas
gas recommended by the manufacturer, which is free of flammable gases and interfering and contaminating substances, the purpose of which is calibration/adjustment of the equipment zero

3.1.9 **standard test gas**
test gas with a composition specified for each item of equipment and gas and/or vapour to be used for all tests unless otherwise stated

3.2 **types of equipment**

3.2.1 **alarm-only equipment**
equipment with an alarm but not having an indication of measured value

3.2.2 **aspirated equipment**
equipment that samples the gas by drawing it to the gas sensor

Note 1 to entry: A hand operated or electric pump is often used to draw gas to the sensor.

3.2.3 **automatically aspirated equipment**
aspirated equipment with an integral pump or separate pump, which is connected directly to the equipment

3.2.4 **continuous duty equipment**
equipment that is powered for long periods of time, but may have either continuous or intermittent sensing

Note 1 to entry: For this edition of the standard, all equipment is regarded as continuous duty.

3.2.5 **diffusion equipment**
equipment in which the transfer of gas from the atmosphere to the sensor takes place without aspirated flow

3.2.6 **equipment, fixed**
equipment fastened to a support, or otherwise secured in a specific location when energized

3.2.7 **Group I equipment**
equipment for mines susceptible to firedamp

3.2.8 **Group II equipment**
equipment for places with an explosive gas atmosphere, other than mines susceptible to firedamp

3.2.9 **equipment, portable**
equipment intended to be carried by a person during operation

Note 1 to entry: A portable equipment is battery powered and includes, but is not limited to

a) a hand-held equipment, typically less than 1 kg, which requires use of only one hand to operate,

b) personal monitors, similar in size and mass to the hand-held equipment, that are continuously operating (but not necessarily continuously sensing) while they are attached to the user, and

c) larger equipment that can be operated by the user while it is carried either by hand, by a shoulder strap or carrying harness and which may or may not have a hand directed probe.

3.2.10 **equipment, transportable**
equipment not intended to be carried by a person during operation, nor intended for fixed installation

3.2.11 **gas detection transmitter**
fixed gas detection equipment that provide a conditioned electronic signal or output indication to a generally accepted industry standard (such as 4 to 20 mA), intended to be utilized with separate gas detection control units or signal processing data acquisition, central monitoring and similar systems, which typically process information from various locations and sources including, but not limited to gas detection equipment

3.2.12 **gas detection control unit**
equipment intended to provide display indication, alarm functions, output contacts and/or alarm signal outputs or any combinations when operated with remote sensor(s)

3.2.13 **separate gas detection control unit**
equipment intended to provide display indication, alarm functions, output contacts or alarm signal outputs or any combination when operated with gas detection transmitter(s)

3.2.14 **equipment with integral sensor(s)**
equipment that provides display indication, alarm functions, output contacts and/or alarm signal outputs using a sensor which is within or directly mounted to the equipment housing

3.2.15 **accessory**
component which can be fitted to the equipment for special purpose

EXAMPLE External gas pump, sampling probe, hoses, collecting cone, weather protection device

3.3 **sensors**

3.3.1 **sensing element**
part of the sensor which is sensitive to the gas/vapour to be measured

3.3.2 **sensor**
assembly in which the sensing element is housed and that may also contain associated circuit components

3.3.3 **integral sensor**
sensor which is within or directly mounted to the equipment housing

3.3.4 **remote sensor**
snsor that is separated from the equipment body and is connected to a gas detection control unit or to a gas detection transmitter.

3.4 **supply of gas to equipment**

3.4.1 **sample line**
means by which the gas being sampled is conveyed to the sensor

Note 1 to entry: Accessories such as filter or water trap are often included in the sample line.

3.4.2 **sampling probe**
separate accessory sample line which is optionally attached to the equipment

Note 1 to entry: It is usually short (e.g. of the order of 1 m) and rigid, although it can be telescopic. In some cases it is connected by a flexible tube to the equipment.

3.4.3 **field calibration kit**
means of presenting test gas to the equipment for the purpose of calibrating/adjusting or verifying the operation of the equipment

Note 1 to entry: The field calibration kit can be used for verifying the operation of the alarms if the concentration of the test gas is above the alarm set-point.

Note 2 to entry: A mask for calibration and test (see 3.4.4) is an example of a field calibration kit.

3.4.4 **mask for calibration and test**
device that can be attached to the equipment to present a test gas to the sensor in a reproducible manner

3.5 **signals and alarms**

3.5.1 **alarm set point**
setting of the equipment at which the measured concentration will cause the equipment to initiate an indication, alarm or other output function

3.5.2 **latching alarm**
alarm that, once activated, requires deliberate action to be deactivated

3.5.3 **fault signal**
audible, visible or other type of output, different from the alarm signal, permitting, directly or indirectly, a warning or indication that the equipment is not working satisfactorily

3.5.4 **special state**
any state of the equipment other than those in which monitoring of gas concentration and/or alarming is the intent

Note 1 to entry: Special state includes warm-up, calibration mode or fault condition.

3.6 **times**

3.6.1 **drift**
variation in the equipment indication over time at any fixed gas volume fraction (including clean air) under constant ambient conditions

3.6.2 **final indication**
indication given by the equipment after stabilization

3.6.3 **stabilization**
state when three successive readings of an equipment at a constant gas volume fraction, taken at 2 min intervals or twice the respective $t(90)$, whichever is less, indicates no changes greater than ±1 % of the measuring range

3.6.4 **time of response**
t(x)
time interval, with the equipment in a warmed-up condition, between the time when an instantaneous change between clean air and the standard test gas, or vice versa, is produced at the equipment inlet, and the time when the response reaches a stated percentage (x) of the stabilized signal on the standard test gas

3.6.5 **warm-up time**

time interval, with the equipment in a stated atmosphere, between the time when the equipment is switched on and the time when the indication reaches and remains within the stated tolerances

Note 1 to entry: See Figure 1 and Figure 2.

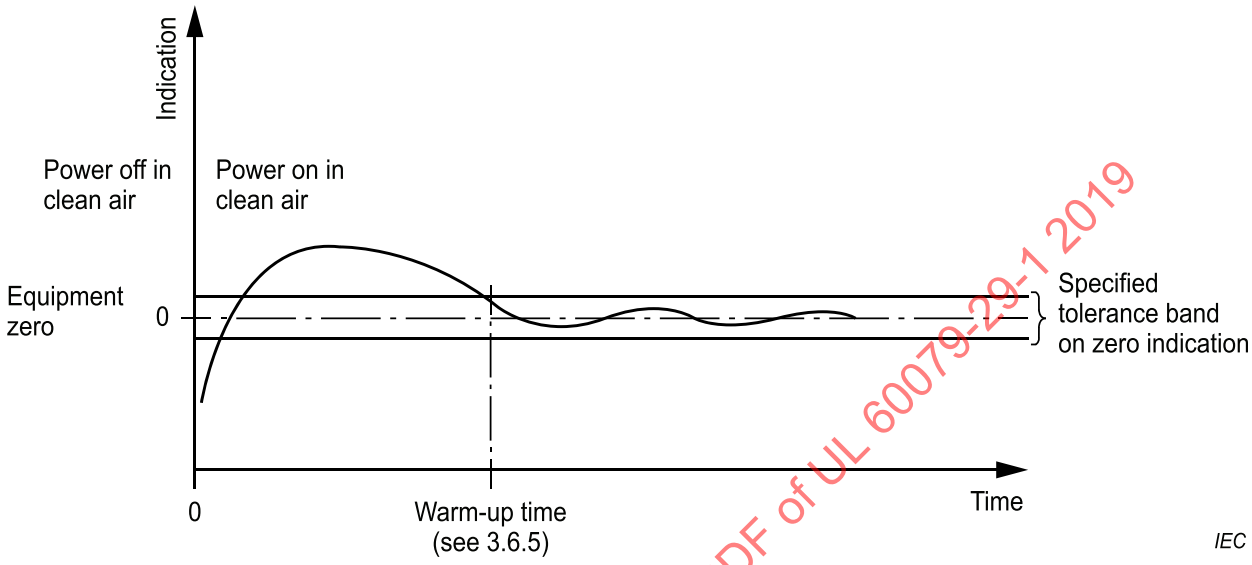

Figure 1
Warm-up time in clean air (typical)

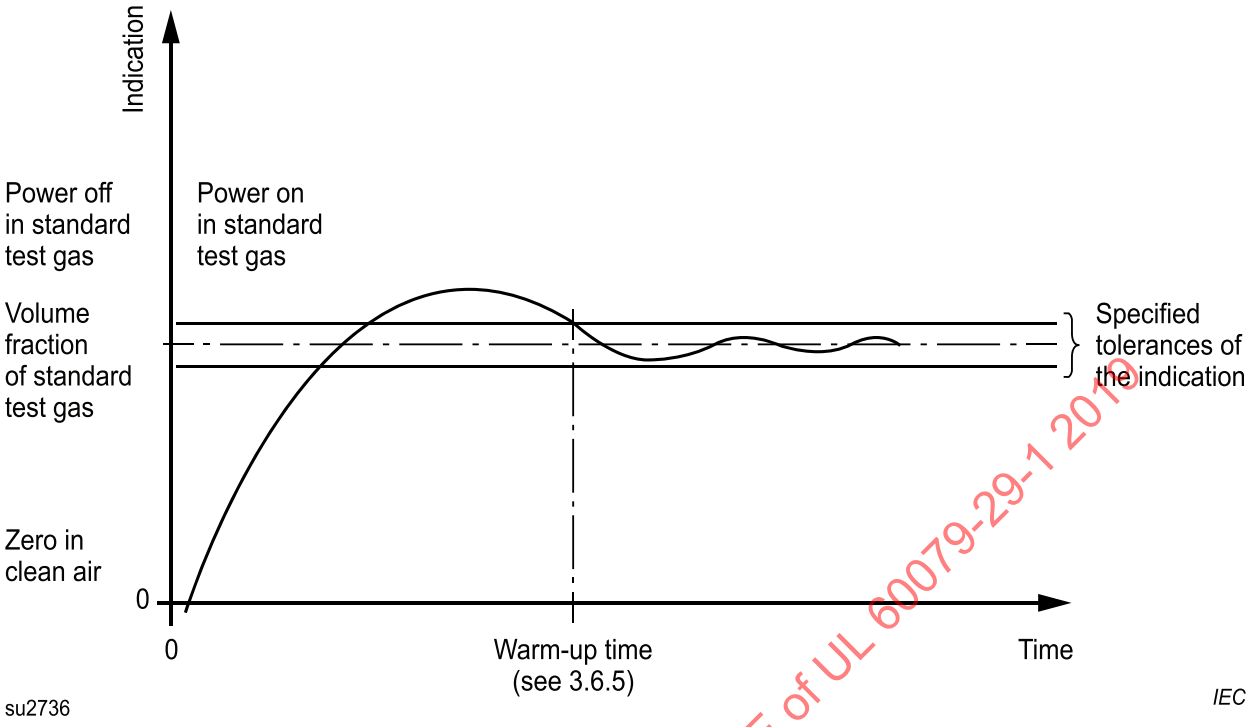

Figure 2
Warm-up time in standard test gas (typical)

3.7 **miscellaneous**

3.7.1 **special tool**
tool required to gain access to, or to adjust the equipment controls

Note 1 to entry: The design of the tool is intended to discourage unauthorised interference with the equipment.

4 General requirements

4.1 Overview

4.1.1 Manufacturer claims

4.1.1DV D2 ***Modification of Clause 4.1.1, first paragraph to replace with the following:***

The equipment shall conform to the requirements of this ~~part of IEC 60079-29~~ standard and Annex A criteria.

Where an equipment manufacturer makes any claims in the instruction manual regarding any special features of construction or superior performance that exceed these minimum requirements, all such claims shall be verified and the test procedures shall be carried out as stated in each clause and shall be extended or supplemented, where necessary, to verify the claimed performance.

When verifying a manufacturer's claimed performance or special features of construction, the minimum requirements of the standard shall be met and the manufacturer's claimed performance shall be verified. Any additional tests shall be agreed upon by the manufacturer and test laboratory and identified and described in the test report.

EXAMPLE When a manufacturer claims a sensor accuracy over a defined temperature range of –50 °C to +55 °C at ±15 %LFL (assuming a measuring range of 0 to 100 %LFL), the sensor must meet the manufacturer's claim from –50 °C to –20 °C and meet the specified requirements of 5.4.6 for the temperature range of –20 °C to +55 °C.

There may be applications where equipment with special features are needed. One example may be a gas detector intended to be used in coal mines with a measuring range up to 10 % (v/v) methane but with the accuracy requirements of 5 % (v/v) methane equipment. In such a case it shall be tested like 5 % (v/v) methane equipment.

4.1.2 Equipment ratings

Electrical assemblies and components shall conform to the construction and test requirements of 4.2 and Clause 5, where applicable. In addition, parts of the flammable gas detection equipment intended for use in hazardous areas shall conform to the Type(s) of Protection as specified in the other relevant parts of the IEC 60079 series.

The ambient temperature and pressure ranges of equipment conforming to this standard shall not exceed the ambient temperature and pressure ranges of the Type(s) of Protection.

4.2 Construction

4.2.1 General

Gas detection equipment or parts thereof (e.g. remote sensors) specifically intended for use in the presence of corrosive vapours or gases, or which may produce corrosive by-products as a result of the detection process (e.g. catalytic oxidation or other chemical process) shall be constructed of materials known to be resistant to corrosion by such substances.

All equipment shall be constructed to facilitate regular accuracy checks.

All materials and components used in the construction of the equipment shall be used within the manufacturer's ratings or limitations, unless otherwise specified by appropriate safety standards.

Any malfunction of outputs from the gas detection equipment not relevant to safety or health shall not adversely affect the functions of the equipment related to safety.

EXAMPLE Equipment with 4-20 mA and HART communication where only the 4-20 mA communication is defined in the instruction manual as related to safety. The loss of HART communication is not related to safety.

4.2.2 Indicating devices

4.2.2.1 General

Readily distinguishable indications shall be provided to show that the equipment is energized, in alarm and in special states.

Portable equipment shall provide visual and audible indications for both fault and alarms.

If audible indications are provided for transportable or fixed equipment, alarms shall be indicated as a minimum.

All methods of indication of the measured value shall present the same value within the resolution of each indicator.

The indications related to gas detection transmitters and remote sensors for fixed equipment may be shown only at the (separate) gas detection control unit.

4.2.2.2 Resolution

For alarm-only equipment or equipment where the resolution of the read-out device is inadequate to demonstrate compliance with this standard, the manufacturer shall identify suitable points for connecting indicating or recording devices for the purpose of testing the compliance of the equipment with this standard. The indication on the readout device shall not contradict the results obtained by additional indicating or recording devices.

4.2.2.3 Measuring range

Any over-range measurements shall be clearly indicated as such.

4.2.2.4 Selectable range

If the equipment has more than one measuring range, the range selected shall be clearly identified.

4.2.2.5 Suppression of indication and measured values below zero

It shall be possible to configure the equipment such that in measuring mode any kind of suppression of the measured value is permanently disabled. In calibration mode any kind of suppression of the measured value shall be automatically disabled.

Measured values within the measuring range shall be indicated.

Measured values below 5 % of the measuring range (values below zero included) shall be indicated as:

a) zero,

b) another indication that the measured value is below 5 % of the measuring range or

c) the measured value.

Equipment with a measuring range up to 20 % LFL shall indicate measured values below −10 % of the measuring range or shall provide a fault signal. The equipment shall provide a fault signal at measured values below −20 % of the measuring range at the latest.

All equipment with measuring ranges greater than 20 % LFL shall provide a fault signal at measured values below −10 % of the measuring range at the latest. Portable and transportable equipment shall indicate measured values below −5 % of the measuring range or shall provide a fault signal.

Any suppression of indication shall be explained in the manual (see 4.4 d)).

4.2.2.6 Indicator light

If only one indicator light is provided for signalling alarms, special states and other indications, it shall be coloured red. If separate indicator lights are used or if a multi-coloured indicator light is provided, the colours shall be used in the following order of priority ((a) being highest priority):

a) alarms indicating the presence of a gas concentration beyond an alarm set point shall be coloured RED;

b) equipment special state indicators shall be coloured YELLOW;

c) power supply indicators shall be coloured GREEN.

If there is more than one indicator light of the same colour with different functions, the lights shall be labelled to show their functions. Text, marks, and icons on a screen display describing the indicator lights are permissible in place of printed labels.

4.2.3 Alarm signals

4.2.3.1 General

Alarm devices shall not be adjustable to operate outside the measuring range.

If alarm devices, output contacts or alarm signal outputs are provided as part of continuous duty gas detection equipment and are intended to operate when a potentially hazardous gas concentration is detected, they shall be of a latching type requiring a deliberate manual action to reset. If two or more alarm set points are provided, the lower may be non-latching – based on user preference. Alarms shall remain in operation while the alarm condition is still present, although audible alarms may be silenced if this audible alarm is not the only alarm.

If it is possible to deactivate alarm devices, output contacts or alarm signal outputs, e.g. for calibration purposes, this deactivation shall be indicated by a signal. For fixed equipment, this shall include a contact or other transmittable output signal. However, the output signal or contacts are not required if the alarms are automatically re-enabled within 15 min.

4.2.3.2 Group I portable equipment indicating up to 5 % (v/v)

Alarm devices shall not be adjustable above 3 % (v/v). An additional over-range alarm, which indicates when full scale has been exceeded, may be provided.

4.2.3.3 Group II portable equipment indicating up to 100 % LFL

Alarm devices shall not be adjustable above 60 % LFL. An additional over-range alarm, which indicates when full scale has been exceeded, may be provided.

4.2.4 Fault signals

Fixed and externally powered transportable equipment shall provide a fault signal in the event of failure of power to the equipment.

Externally powered equipment shall provide a fault signal when the power supply falls below the manufacturer's specified minimum supply voltage fault limit.

A short-circuit or open-circuit in connections to any remote sensor or gas detection transmitter shall be indicated by a fault signal.

Under the above conditions the equipment may also indicate alarm.

Measured values below zero (e.g. caused by drift) shall be indicated by a fault signal in accordance with the conditions of 4.2.2.5.

For equipment where the sensor can be disconnected without opening the housing, the equipment shall provide a fault signal in the event of a disconnection of the sensor.

Automatically aspirated equipment shall be provided with an integral flow-indicating device that produces a fault signal in the event of low flow.

4.2.5 Adjustments

All adjustment devices shall be designed so as to discourage unauthorized or inadvertent interference with the equipment. Examples include procedural devices, in the case of a keyboard instrument, or mechanical devices such as a cover requiring the use of a special tool.

Fixed explosion-protected equipment housed in explosion-protected enclosures shall be designed so that, if any facilities for adjustment are necessary for routine recalibration and for resetting or like functions, these facilities shall be externally accessible. The means for making adjustments shall not degrade the explosion protection of the equipment.

The adjustments of the zero and sensitivity shall be designed so that:

a) adjustment of one will not affect the other;

or

b) it shall not be possible to adjust only one and the sequence of adjustments shall ensure that the affected one is adjusted second.

The equipment shall not perform an automatic zero adjustment during start-up. If equipment prompts the user for zero adjustment during start-up and the user makes no selection, equipment shall continue to start-up without zero adjustment, after a delay of no more than 15 s.

4.2.6 Battery-powered equipment

Equipment powered with integral batteries shall be provided with an indication of low battery condition, and the purpose of this indication shall be explained in the manual (see 4.4 j)).

4.2.7 Gas detection transmitter for use with separate gas detection control units

A specification shall be supplied with the equipment that describes the relationship the gas concentration (detected by the equipment) has with the corresponding output signal or indication (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the output signal and the gas concentrations corresponding to 0 %, 10 %, 30 %, 50 %, 70 %, 90 % and 100 % of full-scale output indication. Full-scale output and status signals (e.g. fault, inhibit) shall also be specified by the manufacturer.

Where necessary, equipment shall be provided by the manufacturer to interpret the output signal or indication, which will enable the accuracy of the transfer function to be verified.

4.2.8 Separate gas detection control units for use with gas detection transmitter(s)

A specification shall be supplied with the equipment that describes the relationship the input signal has with the calculated gas concentration (transfer function). Such specification shall be detailed to the extent that the accuracy of this transfer function can be verified. As a minimum, the manufacturer shall provide data showing the relationship between the input signal and the gas concentrations corresponding to 0 %, 10 %, 30 %, 50 %, 70 %, 90 % and 100 % of full-scale output indication. Required inputs for full-scale indication and status signals (e.g. fault, inhibit) shall also be specified by the manufacturer.

Where necessary, equipment shall be provided by the manufacturer to provide the input signals, which will enable the accuracy of the transfer function to be verified.

4.2.9 Software-controlled equipment

4.2.9.1 General

In the design of software-controlled equipment, the risks arising from faults in the programme shall be taken into account by applying the following subclauses. In addition, where accessories are software-controlled, the risks arising from faults in the programme shall be taken into account where related to safety.

4.2.9.2 Conversion errors

The relationship between corresponding analogue and digital values shall be unambiguous. The output range shall be capable of coping with the full range of input values within the equipment specification. A clear indication shall result if the conversion range has been exceeded.

The design shall take into account the maximum possible analogue-to-digital, computational and digital-to-analogue converter errors. The combined effect of digitization errors shall not be greater than the smallest deviation of indication required by this standard.

4.2.9.3 Special state indication

If a special state is entered by the equipment, this shall be indicated by a signal. For fixed equipment, this shall include a contact or other transmittable output signal.

4.2.9.4 Software

Software components shall conform to the following:

a) It shall be possible for the user to identify the installed software version, for example by marking on the installed memory component, in (if accessible) or on the equipment or by showing it on the display during power up or on user command.

b) It shall not be possible for the user to modify the program code.

c) Parameter settings shall be checked for validity. Invalid inputs shall be rejected. An access barrier shall be provided against parameter changing by unauthorized persons, e. g. it may be integrated by an authorization code in the software or may be realized by a mechanical lock. Parameter settings shall be

preserved after removal of power, and while passing a special state. All user changeable parameters and their valid ranges shall be listed in the manual.

d) Software shall have a structured design to facilitate testing and maintenance. If used, program modules shall have a clearly defined interface to other modules.

e) Software documentation shall include:

1) the equipment to which the software belongs;

2) unambiguous identification of the program version;

3) a functional description;

4) the software structure (e.g. flow chart, Nassi-Schneiderman diagram);

5) any software modification provided with the date of change and new identification data.

4.2.9.5 Data transmission

Digital data transmission between spatially separated components of equipment shall be reliable. The measures for ensuring reliable data transmission between spatially separated components shall take into account transmission errors, repetitions, deletion, insertion, resequencing, corruption, delay and masquerade. Delays resulting from transmission errors shall not extend the response time *t*(90) or time to alarm for alarm-only equipment by more than a third. If they do, the equipment shall pass over to a defined special state. The defined special state shall be documented in the instruction manual.

4.2.9.6 Self-test routines

Computerized digital units shall incorporate self-test routines. On failure detection, the equipment shall pass over to a defined special state. The defined special state shall be documented in the instruction manual.

The following minimum tests shall be performed by the equipment:

a) Power supply of digital units shall be monitored within time intervals of maximum ten times response time *t*(90) or time to alarm for alarm-only equipment.

b) All available visible and audible output functions shall be tested. The test shall be carried out automatically after starting operation or on user request. The result may need to be verified by the user.

c) A watchdog or similar mechanism with its own time base shall work independently and separately from the parts of the digital unit, which perform the data processing.

d) Program and parameter memory shall be monitored by procedures, which allow the detection of a single bit error.

e) Volatile memory shall be monitored by procedures that test the readability and writeability of the memory cells.

All tests, except for test b), shall be done automatically and be repeated cyclically at least every 24 h and after switching on.

4.2.9.7 Functional concept

The manufacturer shall provide documentation for functional concept analysis and evaluation using the following list:

– measuring sequence (including all possible variations);

– possible special states;

– parameters and their tolerable adjustment range;

– representation of measuring values and indications;

– generation of alarms and signals;

– extent and realization of test routines;

– extent and realization of remote data transmission.

4.3 Marking

4.3DV ***Modification of Clause 4.3 to replace with the following:***

In addition to the applicable marking requirements of ~~IEC~~ UL 60079-0, the equipment marking shall also include:

a) DR "~~IEC~~ 60079-29-1" (to represent conformance with this performance standard);

b) DE year of construction (may be encoded within the serial number)~~.~~;

c) D2 the marking "CAUTION – READ AND UNDERSTAND INSTRUCTION MANUAL BEFORE OPERATING OR SERVICING" or technically equivalent text.

For portable equipment requiring the use of a protective case in normal operation, the required markings shall not be obscured or shall be reproduced on the protective case.

DR For small gas detection equipment, the "~~IEC~~ 60079-29-1" marking may be placed within the manual.

4.4 Instruction manual

Each equipment shall be provided with an instruction manual that includes the following information as relevant:

a) complete instructions, drawings and diagrams for safe and proper operation, installation and servicing of the equipment;

b) operating instructions and calibration/adjustment procedures including ranges of concentration and humidity of the test gases as well as instructions for the use of the field calibration kit (see also 5.4.22);

c) details for calibration and/or maintenance which shall include the following:

1) recommendations for initial checking and calibration of the equipment on a routine basis including the maximum time interval between calibrations;

2) for portable equipment the requirement and method for performing a functional check with gas before each day of use;

3) recommendations for maintenance to be taken after the measuring range has been exceeded;

4) the procedure to check reaction time when the calibration gas is applied;

5) a recommendation to users to read the procedures described in IEC 60079-29-2 for reference.

d) details of operational limitations, performance claimed by the manufacturer and special features including, where applicable, the following:

1) gases for which the equipment is suitable and the relative sensitivities including tolerances to these gases;

2) information that describes the sensitivities to other gases to which the equipment is responsive;

3) time of response *t*(90) for the standard test gas(es), method of test (diffusion or flow), and *t*(90) for other gases tested in accordance with this standard;

4) temperature limits (explosion protection and performance);

5) humidity limits;

6) pressure limits (explosion protection and performance);

7) supply voltage limits;

8) maximum power consumption;

9) relevant characteristics and construction details of required interconnecting cables;

10) for battery operated equipment, battery type(s) and operating time(s) until low battery condition under normal operating conditions;

11) sample flow rate limits;

12) warm-up time;

13) test gas application time for calibration;

14) nominal orientation and orientation limits (for fixed and transportable equipment);

15) electro-magnetic compatibility (e.g. shielded cable, transient suppression, special enclosure);

16) description of any suppression of indication and method for its enablement/disablement;

17) air velocity limits.

e) details of storage life and limitations for the equipment, replacement parts and accessories, including, where applicable, the following:

1) temperature;

2) humidity;

3) pressure;

4) time.

4.4DV DR *Modification to Clause 4.4, item f) to replace with the following:*

f) bases (source (s) and edition (s), such as ~~IEC 60079-20-1~~ ANSI/NFPA 497) used for converting test and calibration gas concentrations from % LFL to % volume fraction;

g) information on the adverse effects of poisons and interfering gases or substances and oxygen-enriched or deficient atmospheres on the proper performance (and, in the case of oxygen-enriched atmospheres, on electrical safety) of the equipment;

h) for aspirated equipment, indication of the minimum and maximum flow rates and pressure, tubing type, maximum length and size for proper operation;

i) for aspirated equipment, instructions for ensuring that the sample lines are intact and that proper flow is established (see 4.2.4);

j) specification and significance of each alarm (including over-range indication) and fault signal, the default setting of alarms, the duration of such alarms and signals (if timelimited or non-latching), and any provisions that may be made for silencing or resetting such alarms and signals, as applicable;

k) details of any method for the determination of the possible sources of a malfunction and any corrective procedures (i.e. trouble-shooting procedures);

l) a statement that alarm devices, outputs or contacts are of the non-latching types, where applicable (see 4.2.3.1);

m) for battery-operated equipment, installation and maintenance instructions for the batteries;

n) a recommended replacement parts list;

o) where optional accessories (e.g. collecting cones, weather-protecting devices, field calibration kit) are supplied, a list of such accessories and their effects on the instrument characteristics (including response time and sensitivity), and means for their identification (e.g. part numbers). In addition, it shall be clearly described for each accessory whether it is included in the performance certificate. Consideration shall be given to the effects of the use of the accessory on the measurement of different gases (see d)1) and d)3));

p) details of performance certification, if any (e.g. issuing organisation, date, ranges, gases, accessories, etc.), and marking, and any special conditions of use;

q) if an ingress protection (IP) is claimed, such as IEC 60529, the following statement shall be included:

1) IP ratings do not imply that the equipment will detect gas during and after exposure to those conditions.

2) recommendations for determining appropriate calibration interval and maintenance requirements if exposed to those conditions representative of the IP rating;

3) recommended accessories to those conditions representative of the IP rating

r) for gas detection transmitter or separate gas detection control units, specification of the transfer function, full scale input/output and all status signals (e.g. fault, inhibit) (see 4.2.7 and 4.2.8);

s) for gas detection transmitter or separate gas detection control unit, information that the time of response of the entire system is determined by the time of response of all parts of equipment within the gas detection system;

t) for gas detection control unit or separate gas detection control unit, the maximum delay time until special state is entered in case of transmission errors;

u) any necessary instructions or information, where the special nature of the equipment (such as non-linear responses) requires additional instructions or special information that are alternative to, or in addition to, the requirements of 4.3 and 4.4 a) to r).

5 Test methods

5.1 Overview

The test methods and procedures described in 5.2 to 5.4 are intended as a basis for establishing whether the equipment conforms with the supplementary requirements for performance given in Annex A.

5.2 General requirements for tests

5.2.1 General

5.2.1DV DR *Modification of Clause 5.2.1 to replace with the following:*

Where it is necessary to apply LFL and UFL values for the purposes of this standard, reference shall be made to ~~IEC 60079-20-1~~ ANSI/NFPA 497.

5.2.2 Samples and sequence of tests

5.2.2.1 General

5.2.2.1DV DR *Modification of Clause 5.2.2.1 to replace with the following:*

For the purpose of type testing, all the tests shall be carried out on the same sample except for tests 5.4.4.3 to 5.4.4.6 in combination with 5.4.16, 5.4.20 and for test 5.4.21, each of which may be conducted on separate samples.

If a test sample ceases to function during the test sequence, then the test laboratory shall decide which tests have to be repeated with a replacement sample. The decision and its justification shall be described in the test report.

5.2.2.2 ~~Optical filter~~

5.2.2.2DV DR *Delete Clause 5.2.2.2.*

It does not apply.

~~For IR-sensors with optical filters, where relative sensitivities with tolerance less than 20 % of the stated value are specified within the instruction manual (see 4.4 d)1), the test 5.4.3.3 shall be conducted with two samples where the centre wavelength of the optical filters shall be at the minimum and maximum limits of the specification. One of these units may be used subsequently for 5.4.4.3 to 5.4.4.6, 5.4.16 and 5.4.20.~~

5.2.2.3 Sequence

5.2.2.3DV.1 DR *Modification of Clause 5.2.2.3, first paragraph to replace with the following:*

5.2.2.3DV.1.1 The unpowered storage test (5.4.2) shall be conducted prior to all remaining tests. The vibration test (5.4.12) shall be performed after unpowered storage testing for pre-conditioning purposes except for separate test samples used for the tests in 5.4.4.3 to 5.4.4.6, 5.4.16, 5.4.20 or 5.4.21 .

All remaining tests shall be performed to a schedule agreed upon between the manufacturer and the test laboratory. However, the tests 5.4.4.3 to 5.4.4.6 and 5.4.16 shall always be conducted sequentially.

If the design of equipment, which has been tested previously to this standard, is modified then the test laboratory shall agree with the manufacturer which tests have to be repeated with the modified equipment. The decision and its justification shall be described in the test report.

In the case of modifications to the software or of electronic components which are part of the basic gas detection functionality (signal chain from sensor to output(s)) the following tests shall be re-performed as a minimum: calibration curve, alarm set point(s), time of response.

5.2.2.4 Gas detection transmitter(s)

5.2.2.4DV DR *Modification of Clause 5.2.2.4 to replace with the following:*

Gas detection transmitter(s) shall be tested to the applicable requirements of 5.4.2 through 5.4.12 and 5.4.14 through 5.4.23 using the parameters of the transfer function.

5.2.2.5 Separate gas detection control units

5.2.2.5DV DR *Modification of Clause 5.2.2.5 to replace with the following:*

Separate gas detection control units shall be tested to the applicable requirements of 5.4.2, 5.4.3, 5.4.5, 5.4.6, 5.4.12, 5.4.14 through 5.4.18, 5.4.21, ~~and~~ 5.4.23 and 5.4.24DV using the parameters of the transfer function(s).

5.2.3 Preparation of equipment before testing

5.2.3DV.1 DE *Modification of Clause 5.2.3, first paragraph to replace with the following:*

5.2.3DV.1.1 The equipment shall be prepared and mounted as near to typical use as possible, in accordance with the instruction manual, including all necessary interconnections, initial adjustments and initial calibrations. Adjustments such as calibration may be made, where appropriate, at the beginning of each test in 5.4.2 to 5.4.23.

During each test, no adjustment shall be made. Suppression of indications of the equipment under test shall be disabled.

Optional accessories to be included in the performance test shall be either attached or removed according to which condition will give the most unfavourable result for the test being conducted unless otherwise specified. The exact configuration of the equipment, including use of or removal of the optional accessories, shall be included in the test report.

EXAMPLE Weather protection is an example of an optional accessory.

In particular, the following points shall be noted:

a) All equipment having remote sensors:

– For the purpose of the tests in 5.4, where reference is made to exposure of the sensor to the test conditions, the entire remote sensor (including any or all normally attached protective mechanical parts) shall be exposed.

– For equipment having connection facilities for more than one remote sensor, only one remote sensor needs to be subjected to the tests. The replacement of all but one sensor by "dummy" impedances yielding the worst case load conditions for the test in question shall be permitted. The worst case load conditions shall be determined by the testing laboratory within the limits specified in the instruction manual (see 4.4 d)).

– For equipment having remote sensor(s), all tests shall be performed with resistances connected in the detector circuit to simulate the maximum line resistance specified by the manufacturer, except where minimum line resistance offers a more stringent test in the judgement of the test laboratory.

b) Separate gas detection control units:

The replacement of all transmitters by appropriate signal sources and worst case loads for the test in question shall be permitted. The worst case loads shall be determined by the test laboratory within the limits specified in the instruction manual (see 4.4 d)).

c) All equipment having integral sensors:

The entire equipment shall be exposed to the test conditions without removal of any normally attached parts, including any sampling probe for tests 5.4.10, 5.4.14 and 5.4.15.

d) Alarm-only equipment:

For alarm-only equipment, readings shall be taken using an indicating or recording device connected to the test points described in 4.2.2.2.

5.2.4 Mask for calibration and tests

When a mask is used for calibration or for the injection of test gas into the sensor, the design and operation of the mask used by the testing laboratory – in particular the pressure and velocity inside the mask – shall not influence the response of the equipment or the results obtained.

The manufacturer may provide a suitable calibration mask together with details of pressure or flow for application of calibration gases with the equipment.

5.3 Normal conditions for test

5.3.1 General

The test conditions specified in 5.3.2 to 5.3.12 shall be used for all tests, unless otherwise stated.

5.3.2 Test gas(es)

The flammable gas(es) to be used in a mixture with clean air for initial and all subsequent tests shall be selected in accordance with a) to d) with decreasing priority.

a) The specific gas for equipment intended for sensing a single flammable gas only.

b) Methane for equipment intended for sensing methane or firedamp.

c) Methane, and propane or butane for equipment intended for general purpose flammable gas detection (in order to get representative results, e.g. concerning sensitivity, response times and drift).

d) A gas from the manufacturer's list of flammable gases for which the equipment is claimed to be suitable. The choice of this gas should be made by agreement between the manufacturer and the test laboratory.

For all the other gases for which the equipment is claimed to be suitable, the calibration curves and response times shall be supplied by the manufacturer and a representative sample verified by the testing laboratory. The tolerance on the nominal volume fraction of all test gases shall not exceed ±10 %. The volume fraction of the component within the test gas(es) shall be known to a relative expanded uncertainty of ±2 % of the nominal value.

For the purpose of this standard, where it is appropriate to use zero gas rather than clean air, references to clean air may be regarded as references to zero gas.

The gas mixture may be prepared by any suitable method, for example in accordance with the methods outlined in ISO 6142 or ISO 6145, or by commercially produced certified gas mixtures.

5.3.3 Standard test gas

The volume fractions of the standard test gases shall be as follows:

a) for Group I equipment indicating up to a volume fraction of 5 % methane: equivalent range of either a volume fraction of (1,5 ± 0,15) % or a volume fraction of (2,0 ± 0,2) %, as agreed between the manufacturer and the testing laboratory;

b) for other Group I and all Group II equipment: 45 % to 55 % of the measuring range, not within the explosive range wherever possible. If this concentration is within the explosive range, the flammable gas shall be mixed with nitrogen if the measuring function of the equipment is not affected by oxygen deficiency. Otherwise the volume fraction of the standard test gas shall be taken outside the explosive range as near as possible to the values stated above.

The volume fractions shall be known to a relative expanded uncertainty of not greater than ±2 %.

5.3.4 Flow rate for test gases

When the equipment is exposed to the test gases, including air, the flow rate of the gas shall be in accordance with the instruction manual.

For equipment that samples by diffusion, either a calibration mask in accordance with 5.2.4 or a test chamber may be used.

5.3.5 Voltage

a) Mains-powered and fixed DC powered equipment shall be operated within 2 % of the manufacturer's rated voltage and frequency.

b) Battery-powered equipment shall, for short-term tests, be equipped with new or fully charged batteries at the commencement of each series of tests. For long-term testing, it is permissible to energize the unit from a stabilized power supply. The temperature test (5.4.6) shall be carried out with all batteries specified in the instruction manual.

5.3.6 Temperature

The ambient air and test gas shall be held at a temperature constant to ±2 °C within the range of 15 °C to 25 ° C, throughout the duration of each test, unless otherwise specified for the particular test. This requirement is not applicable to tests 5.4.12 and 5.4.21.

5.3.7 Pressure

The tests shall be performed at the prevailing ambient pressure provided that it lies between 86 kPa and 108 kPa. If a deviation greater than ±1 kPa occurs during a test, the pressure changes shall be recorded and taken into account, using the results of the pressure test (5.4.7).

5.3.8 Humidity

The ambient air, zero gas and test gas shall be held at a relative humidity (RH) over the range 20 % to 80 % throughout each test unless otherwise specified for the particular test. The humidity of zero gas and test gas shall be controlled to within ±10 % RH. This requirement is not applicable to tests 5.4.12 and 5.4.21.

For short applications of test gases (up to 8 hours), the use of dry gases is permitted. The properties of the measuring principle of the sensor shall be taken into account.

5.3.9 Acclimation time

In each instance where the equipment is subjected to a different test condition, the equipment shall be allowed to stabilize under these new conditions before measurements are taken.

5.3.10 Orientation

The equipment shall be tested in the orientation recommended by the manufacturer.

5.3.11 Communications options

For equipment that has serial or parallel communications options used during normal gas detection operation, tests in 5.4.3.2, 5.4.6 and 5.4.15 shall be performed with all communication ports connected. The maximum transaction rate, cabling characteristics and activity level specified by the instrument's manufacturer shall be employed.

5.3.12 Gas detection equipment as part of systems

For gas detection equipment that are part of systems, tests in 5.4.3.2, 5.4.6, 5.4.15 and 5.4.18 shall be performed with the maximum system communications transaction rate and activity level. This shall correspond to the largest and most complex system configuration permitted by the manufacturer.

5.4 Test methods

5.4.1 General

Tests shall be carried out, where applicable, to ensure that the equipment satisfies the construction requirements of 4.2. Most of the requirements for these tests are self-evident. For short-circuit requirements in 4.2.4, each wire connecting the equipment to any remote sensor or gas detection transmitter shall be substituted with a load resistor. The values of these resistors shall be equivalent to the maximum wire resistance for the cable specified in the instruction manual (see 4.4 d)). The device used for the short circuit shall be of negligible resistance and shall be applied at the remote sensor or gas detection transmitter ends of the load resistors.

The marking of the equipment and the contents of the instruction manual shall be confirmed against 4.3 and 4.4.

The following tests shall be performed in accordance with 5.3, unless otherwise stated. All tests shall be performed. At the end of each test, indications shall be taken in both clean air and the standard test gas, unless otherwise stated. The values of the indications used for verification of compliance with the performance requirements of Annex A shall be the final indications (see 3.6.2) of both the clean air and standard test gas readings, unless otherwise stated. If, however, the sensor characteristics do not allow the equipment to stabilize within 6 min, then a time shall be agreed between the manufacturer and the test laboratory when the equipment is deemed to be stabilized. This time shall not exceed 6 min and shall be specified in the instruction manual as the test gas application time for calibration. This time shall also be used for calibration and adjustment of the equipment, and when performing test 5.4.15.

For equipment having more than one selectable range for the same or different gases or vapours, each range shall be tested. For the second and subsequent ranges the necessary amount of testing shall be agreed upon between the manufacturer and the test laboratory.

For equipment where different ranges are achieved by using different sensors, each range shall be subjected to the full series of tests.

5.4.2 Unpowered storage

All parts of the equipment shall be exposed sequentially to the following conditions in clean air only:

a) a temperature of (–25 ± 3) °C for at least 24 h;

b) ambient temperature for at least 24 h;

c) a temperature of (60 ± 2) °C for at least 24 h;

d) ambient temperature for at least 24 h.

At each temperature, the humidity of the clean air shall be such that condensation does not occur.

5.4.3 Calibration and adjustment

5.4.3.1 Initial preparation of the equipment

The equipment shall be calibrated and adjustments shall be carried out to obtain correct indications in accordance with the manufacturer's instruction manual.

5.4.3.2 Calibration curve

The equipment shall be exposed to the gas selected in accordance with 5.3.2, at 0 %, 10 %, 30 %, 50 %, 70 % and 90 % of the measuring range, starting with the lowest and finishing with the highest of the selected volume fractions. However, the highest volume fraction may be reduced for equipment with low measuring ranges in order to prevent over-range indications within the performance limits.

This operation shall be carried out three times consecutively.

5.4.3.3 Response to different gases

For Group II equipment, the accuracies of the response curves or correction charts provided in the instruction manual shall be checked by measuring the response for the representative gases in accordance with 5.3.2, at a minimum of three different volume fractions spread evenly over the measuring range to verify response characteristics. This operation shall be carried out two times consecutively.

The ratio between the indication of the equipment (before correction using the manufacturer's response curve or correction charts) and the gas volume fraction obtained for each of the three gas volume fractions of each gas tested shall not be less than 0,4 and shall not exceed 2,0.

Equipment with semiconductor or catalytic sensors shall then be exposed to the test gas with a volume fraction between 45 % to 55 % of the measuring range for (60 +2/0) min and the deviation of the indication during the exposure measured.

5.4.4 Stability

5.4.4.1 Battery-powered equipment for stability

For these tests, battery-powered equipment should be powered from internal batteries wherever possible, otherwise an external power supply may be used.

5.4.4.2 Short-term stability

The equipment shall be exposed to six applications of the standard test gas for 3 min followed by exposure to clean air for a period of 7 min. Indications shall be taken at the end of each exposure to clean air and the standard test gas.

5.4.4.3 Long-term stability (fixed and transportable equipment – Group I only)

The equipment shall be operated in clean air continuously for a period of (28 +1/0) days and shall be exposed to the standard test gas for an (480 +10/0) min period at (7 ± 1) day intervals over the test period. Indications shall be taken prior to the application of, after stabilization and prior to removal of the standard test gas.

After this first period, the following procedure shall be performed.

The equipment shall be exposed to a methane-air mixture with a volume fraction of 1,0 % (v/v) ± 0,05 % (v/v) for (168 ± 4) hours, a minimum of 5 indications being taken no less than 24 hours apart in clean air and the standard test gas. One of these indications shall be taken at the beginning of the test and another at the end of the test.

5.4.4.4 Long-term stability (portable equipment – Group I only)

The equipment shall be operated in clean air continuously for a period of (480 +10/0) min per working day over a total of 20 consecutive working days. The equipment shall be exposed to the standard test gas for (60 ± 2) min during each operating period. Indications shall be taken prior to the application of, after stabilization, and prior to removal of the standard test gas.

After this first period, the following procedure shall be performed starting at the next working day.

The equipment shall be operated in a methane-air mixture with a volume fraction of 1,0 % (v/v) ± 0,05 % (v/v) for (480 ± 2) min, taking indications in clean air and the standard test gas at the end of this period. The equipment shall then be switched off and exposed to clean air over night. This cycle shall be repeated for a further 4 consecutive working days.

5.4.4.5 Long-term stability (fixed and transportable equipment – Group II only)

The equipment shall be operated continuously in clean air for a period of (63 ± 1) days. On the eighth day, the equipment shall be exposed to the standard test gas for a (480 +10/0) min period. Indications shall be taken prior to the application of test gas, after stabilization of the reading and prior to the removal of test gas.

At the end of each subsequent (7 ± 1) day period, the equipment shall be exposed to the standard test gas until the reading has stabilized. Indications shall be taken prior to the application of test gas and after stabilization of the reading.

5.4.4.6 Long-term stability (portable equipment – Group II only)

The equipment shall be operated continuously in clean air for a period of (420 +5/0) min and then exposed to the standard test gas for another (60 +5/0) min. Indications shall be taken prior to the application of test gas, after stabilization of the reading and prior to removal of test gas.

The equipment shall then be operated in clean air continuously for a period of (480 +10/0) min per working day over a total of 19 consecutive working days. The equipment shall be exposed to the standard test gas until the reading has stabilized, once at the end during each operating period. Indications shall be taken prior to the application of test gas and after stabilization of the reading.

5.4.5 Alarm set point(s)

5.4.5.1 Rising concentration

For equipment with adjustable alarm set points, set the alarm set point at 10 % relative below the concentration of the standard test gas.

If the alarm set point cannot be set at this concentration, the alarm shall be set as near as possible to that concentration. In this case and for equipment with fixed alarm set points the test gas shall have a volume fraction of 10 % relative above the concentration of the alarm set point.

The equipment shall be adjusted with clean air and standard test gas or the specified test gas. Then expose the equipment to clean air and then to the standard test gas or the specified test gas until alarm activation or twice the respective *t*(90), whichever is less.

For equipment with several alarm set points, this test shall be carried out for each alarm set point.

5.4.5.2 Falling concentration (for equipment with measuring range over UFL only)

For equipment with adjustable alarm set points, set the alarm set point at UFL plus 10 % of the measuring range. If the alarm set point cannot be set at this concentration the alarm shall be set as near as possible to that concentration.

The specified test gas shall have a volume fraction of the alarm set point minus 5 % of the measuring range.

The equipment shall be adjusted with standard test gas and clean air or the specified test gas. Then expose the equipment to a test gas with a volume fraction of 90 % of the measuring range and then to the specified test gas until alarm activation or twice the respective *t*(90), whichever is less.

For equipment with several alarm set points, this test shall be carried out for each alarm set point.

5.4.6 Temperature

This test shall be performed in a temperature chamber having the capability of holding the remote sensor or equipment at the specified temperature within ±2 °C. The remote sensor or equipment shall be acclimated at each temperature specified in Annex A, as appropriate, for at least 3 h or until acclimated within ±2 °C for a minimum of 1 h. The remote sensor or equipment shall be exposed sequentially to clean air and the standard test gas, which shall be at the same temperature as the atmosphere in the test chamber. The dew point of the air or standard test gas shall be below the lowest temperature of the test chamber.

For battery powered equipment, the test shall be carried out with all batteries specified in the instruction manual.

5.4.7 Pressure

The effects of pressure variation shall be observed by placing the remote sensor or equipment (including the aspirator for aspirated equipment) in a test chamber that permits the pressure of clean air and of the standard test gas to be varied over the range specified in Annex A.

The pressure shall be maintained at the specified levels within ±0,5 kPa for 5 min, before a reading is accepted or a test is made. Readings shall be taken with clean air and standard test gas.

5.4.8 Humidity of test gas

The test shall be conducted at temperature of (40 ± 2) °C. After an acclimation time of at least 2 hours at 40 °C, the equipment shall be calibrated and adjusted in accordance with the instruction manual (see 4.4 b) and 4.4 d)13)). The sensor shall be exposed for (60 +5/0) min to clean air humidified to (20 ± 5) % RH. The sensor shall then be exposed to the standard test gas humidified to (20 ± 5) % RH until stabilized. The procedure shall be repeated with humidities of (50 ± 5) % RH and (90 ± 5) % RH. The concentration of the test gas shall be held constant, or due allowance of changes in its concentration by dilution in water shall be made.

All relative humidity shall be considered as water vapour volume fractions at the nominal temperature of 40 °C.

5.4.9 Air velocity

This test is applicable to diffusion equipment only.

The equipment or the remote sensor shall be tested in a flow chamber in both clean air and standard test gas.

For equipment with integral sensors, which are too large to be tested in a flow chamber, other flow equipment for carrying out the test shall be permitted. In this case the "other flow equipment" shall be described in the test report.

The sensor shall be operated in the orientation recommended by the manufacturer. If there is no such recommendation e.g. for portable equipment, a typical orientation shall be used.

Irrespective of whether a flow chamber or other flow equipment is used, the direction of the air flow with respect to the sensor inlet shall be as follows:

1) flow directed at the sensor inlet;

2) flow directed 180° to 1);

3) flow directed 90° to 1).

Each orientation is given with a tolerance of ±5°.

5.4.9DV.1 DE *Modification of Clause 5.4.9, seventh paragraph to replace with the following:*

5.4.9DV.1.1 Air velocity flow measurement shall be made at the intended sensor inlet location prior to placing the equipment under test in place. A homogenized gas concentration m~~M~~easurement shall be made ~~under~~ at:

- **(0 + 0,3) m/s ~~non-forced ventilation conditions~~**
- **~~at~~ (3 ± 0,3) m/s and**
- **~~at~~ (6 ± 0,6) m/s.**

Directions of flow which are prohibited within the instruction manual shall not be tested.

5.4.10 Flow rate for aspirated equipment

The equipment shall be tested by varying the flow rate in both clean air and standard test gas

1) from the nominal flow rate to 130 % of the nominal flow rate, if possible

2) from the nominal flow rate to 110 % of the flow rate at which the flow failure signal is activated, or to 50 % of the nominal flow rate if a flow failure signal is not provided.

5.4.11 Orientation

5.4.11.1 Portable equipment

During tests with clean air and standard test gas, rotate the sensor, or the whole equipment if relevant, through 360° in steps of 90° around each of its three mutually perpendicular axes (one axis at a time). Record the indication in each position.

5.4.11.2 Fixed and transportable equipment

Test the equipment or remote sensor with clean air and standard test gas within the orientation limits stated in the manufacturer's instructions, but in no case less than a deviation of ±15° from the nominal orientation.

5.4.12 Vibration

5.4.12.1 Test equipment

The vibration test machine shall consist of a vibrating table capable of producing a vibration of variable frequency and amplitude with the test equipment mounted in place, as required by IEC 60068-2-6 and the following test procedures.

5.4.12.2 Procedures

5.4.12.2.1 General

The test shall be carried out in accordance with IEC 60068-2-6.

The equipment shall be energized and mounted on the vibration test machine and vibrated successively in each of three planes respectively parallel to each of the three major axes of the equipment.

An adjustable alarm set point shall be set to 20 % of measuring range.

Before, and at the conclusion of the test, the equipment shall be exposed to clean air followed by the standard test gas.

The equipment shall be mounted on the vibration table in the same manner as intended for use including any resilient mounts, carrier or holding devices that are provided as standard parts of the equipment.

The equipment shall be vibrated over the frequency range specified at the excursion or constant acceleration peak specified, for a period of at least 1 h in each of the three mutually perpendicular planes. The frequency shall continuously change exponentially with time and the rate of change of frequency shall be one octave per minute.

5.4.12.2.2 Procedure 1

For remote sensors and all equipment with integral sensors, the vibration shall be as follows:

10 Hz to 31,5 Hz, 0,5 mm displacement amplitude (1,0 mm peak-peak total excursion)

31,5 Hz to 150 Hz, 19,6 m/s^2 acceleration amplitude

5.4.12.2.3 Procedure 2

For all other equipment, the vibration shall be as follows:

10 Hz to 31,5 Hz, 0,5 mm displacement amplitude (1,0 mm peak-peak total excursion)

31,5 Hz to 100 Hz, 19,6 m/s^2 acceleration amplitude

5.4.13 Drop test for portable and transportable equipment

If the manufacturer recommends that the instrument be used in its protective casing, the test shall be carried out with the protective casing installed.

If components of fixed equipment can be used like portable or transportable equipment according to the instruction manual, these components should be considered to be portable or transportable for this test.

Before, and at the conclusion of the test, the equipment shall be exposed to clean air followed by the standard test gas.

Portable equipment shall be released, while operating, from a height of (1 +0,05/0) m above a concrete surface and allowed to free fall.

Transportable equipment with a mass less than 5 kg shall be released, while not operating, from a height of (0,3 +0,03/0) m above a concrete surface and allowed to free fall.

Other transportable equipment shall be released, while not operating, from a height of (0,1 +0,02/0) m above a concrete surface and allowed to free fall.

All heights are measured from the lowest point of the equipment.

The test required above shall be performed three separate times, the portable equipment being released each time with a different side (surface) facing down at the time of release and the transportable equipment to be in an orientation for normal transport.

The equipment shall be considered to have failed this test if there is a loss of function (e.g. alarm, pump function, controls, display) after the test.

Automatic re-starting or shut-down of the equipment shall not occur during the test.

5.4.14 Warm-up time

An adjustable alarm set point shall be set to 20 % of the measuring range.

The equipment shall be switched off and left for at least 24 h in clean air. After the 24 h period, the equipment shall be switched on in clean air and the warm-up time measured.

Group I equipment shall be switched off for a further 24 h in clean air. After this period, the equipment shall be exposed for (5 +0,5/0) min to the standard test gas, then switched on in the presence of the test gas and the warm-up time measured.

Where equipment prompts the user to perform any adjustment during start-up, the test shall be applied for the ‘Yes’ and ‘No’ options.

5.4.15 Time of response

The equipment shall be switched on in clean air and, after an interval corresponding to at least two times the warm-up time, as determined in accordance with 5.4.14, without switching off, the equipment or the sensor(s) shall be subjected to step changes from clean air to the standard test gas and from standard test gas to clean air. These changes shall be introduced by means of suitable equipment (see Annex B).

The times of response $t(50)$ and $t(90)$ for increasing concentration, and $t(50)$ and $t(10)$ for decreasing concentration shall be measured.

For an optional sampling probe, an extra test is required to measure the additional delay. This shall be less than 3 s/m of the total length of the probe plus tubing or any greater value, which is stated in the instruction manual.

5.4.16 High gas concentration operation above the measuring range

This subclause applies to all equipment with an upper limit of the measuring range less than 100 % (v/v) gas.

The sensor shall be subjected to the test using test equipment that simulates a step change between gas concentrations such as those described in Annex B.

The sensor shall be subjected to a step change from clean air to a volume fraction of 100 % (v/v) gas that shall be maintained for (180 +5/0) s. The equipment or remote sensor shall then be subjected to clean air for (20 +2/0) min, followed by the standard test gas.

All gas concentrations above full scale shall be indicated by a full scale indication and, where fitted, an alarm. If the indication is digital, a clear indication shall be given that the upper limit of the measuring range has been exceeded.

All gas alarms shall remain in operation at all gas concentrations above full scale. If the equipment provides a latching alarm feature, the latching feature shall be verified during and after application of the high gas concentration.

5.4.17 Battery capacity

5.4.17.1 Battery discharge

With a battery fully charged at the beginning of the test, the equipment shall be operated at maximum load condition with consideration to quantity and type of sensors in clean air for a total period of

a) (480 +5/0) min, if fitted with a user-operable on/off switch;

b) (600 +5/0) min, if not so fitted; or

c) any longer time as specified by the manufacturer.

At the beginning and end of the specified period, the equipment is exposed to clean air and the standard test gas.

5.4.17.2 Low battery duration

The equipment shall then continue to operate until an indication that the low battery condition has been reached. The equipment shall continue to operate for at least an additional (10 +0,5/0) min and then be exposed to the standard test gas.

Where it is impractical to discharge the equipment continuously, the equipment may be switched off (e.g. overnight) to ensure the low battery condition is observed in the required time.

5.4.18 Power supply variations

The equipment shall be set up under normal conditions (see 5.3), at rated voltage and, where appropriate, rated frequency. For equipment with remote sensors, the test shall be performed with both maximum and minimum resistance of the interconnecting cable. The equipment shall then be subjected to the following tests.

The equipment calibration shall be checked at both 115 % and 80 % of rated voltage and at +2 % above the minimum supply voltage fault limit.

Where the manufacturer of the equipment specifies a supply range other than those specified above, the equipment shall be tested at the upper and lower limits of the supply voltage specified by the manufacturer.

It shall be verified at +2 % above the minimum supply voltage fault limit that all output functions are working properly even at the worst case load conditions.

Analogue outputs shall be tested at the maximum output level. Relays shall be able to energize at +2 % above the minimum supply voltage fault limit.

5.4.19 Addition of sampling probe

When it is intended to add a sampling probe, the equipment shall first be calibrated using clean air and the standard test gas without the sampling probe. The sampling probe shall then be added, and clean air and standard test gas applied again.

5.4.20 Other gases and poisons

5.4.20.1 Other gases

The equipment shall be tested separately with the following gas mixtures:

a) Group I equipment indicating up to a volume fraction of 5 % methane in air:

1) a methane volume fraction of the standard test gas + a volume fraction of 13 % oxygen in nitrogen;

2) a methane volume fraction of the standard test gas + a volume fraction of 5 % carbon dioxide in air;

3) a methane volume fraction of the standard test gas + a volume fraction of 0,075 % ethane in air.

b) Group I equipment indicating up to a volume fraction of 100 % methane in air:

1) a volume fraction of 50 % methane + a volume fraction of 6,5 % oxygen in nitrogen;

2) a volume fraction of 50 % methane + a volume fraction of 5 % carbon dioxide in nitrogen;

3) a volume fraction of 50 % methane + a volume fraction of 2,5 % ethane in nitrogen.

The gas mixtures may be prepared by any suitable method. The tolerances on the volume fraction of each component shall be within ±10 % of its nominal concentration.

The volume fraction of each component shall be known to a relative expanded uncertainty of ±2 % of the stated value.

5.4.20.2 Poisons (applicable only to Group I equipment with catalytic or semiconductor sensors)

The equipment shall be exposed to a volume fraction of (1,0 ± 0,05) % methane in air mixture containing a volume fraction of (10 ± 1) ppm of hexamethyldisiloxane and shall perform in continuous operation until a dose of (400 ± 20) ppm min is reached.

NOTE 1 Certain materials that might be present in industrial atmospheres can lead to "poisoning" or other undesirable effects which can result in a change of sensitivity of a gas sensor.

NOTE 2 As improved tolerances to these materials are frequently claimed by manufacturers, evidence of the testing procedure used to substantiate these claims and test results can be open to validation or verification by agreement between a purchaser, a manufacturer, and a testing laboratory. Possible "poisoning" agents and their effects on sensor performance are discussed in IEC 60079-29-2.

NOTE 3 The time the equipment is exposed is calculated by dividing the required dose by the actual concentration of hexamethyldisiloxane.

5.4.21 Electromagnetic compatibility

5.4.21DV DR *Modification to Clause 5.4.21 to replace with the following:*

5.4.21DV.1 Test

The equipment, including the sensor and interconnecting wiring, shall be subjected to the tests described in IEC 61326-1:2012 Table 2.

NOTE Specific applications or local regulations might require more severe electromagnetic immunity test parameters.

The test shall be carried out with the equipment exposed to the standard test gas. The alarm set point shall be set so that the alarm is active, i.e. to the volume fraction of the standard test gas plus or minus the variation as listed in Annex A.

For multi-gas portable equipment, this test shall be performed with a full set of typical sensors.

For equipment with a measuring range up to 100 % (v/v), this test shall be performed in clean air only. The alarm set point shall be set to 5 % of the measuring range or the lowest possible setting, whichever setting is higher.

Any special advice in the instruction manual concerning EMC shall be followed.

5.4.21DV.2 Performance criteria

The following hierarchical performance criteria shall apply to all functions of the equipment associated to the detection and measurement of gas:

Performance criterion A:

The equipment shall continue to operate as intended both during and after the test.

For those functions specified by the manufacturer as being safety functions, when the equipment is used as intended no loss of function is allowed and the performance requirements given in Table A.1 shall be complied with.

Performance criterion B:

During the test

- **degradation of performance is allowed but the performance requirements given in Table A.1 shall not be exceeded by more than a factor of 2, or**
- **the equipment shall show a specified fault indication and/or output.**

After the test any degradation in performance shall be self-recoverable and the equipment shall continue to operate as intended. No permanent change of actual operating state or stored data or continuous deactivation of alarm is allowed.

If the equipment includes latching alarms or status signals it is permitted that these may be triggered during the test. After the test signal has been removed, the latching circuits shall be reset and the correct operation of the alarm circuit verified by applying test gas or simulation of signal depending on the type of equipment.

Performance criterion C:

Temporary loss of function is allowed during the test, provided the loss of function is self-recoverable or can be easily restored by the operation of the controls. The equipment shall operate as intended after the test. No change of stored data is allowed.

If performance criterion C is required in IEC 61326-1:2012, the requirements can be presumed to be fulfilled if the equipment complies with performance criterion A or B.

5.4.22 Field calibration kit

Calibration initiation methods and gas application methods shall be tested or excluded from the scope of the performance test within the instruction manual.

Field calibration kit(s) shall be verified by comparison of the following:

a) expose the equipment to clean air and standard test gas using the field calibration kit in accordance with the instruction manual;

b) expose the equipment to clean air and standard test gas as it is done in normal operation.

5.4.23 Software function

5.4.23DV D2 *Modification of Clause 5.4.23 to replace with the following:*

Software controlled equipment shall be validated against the requirements of 4.2.9. Validation evidence of software controlled equipment shall be demonstrated by at least one of the following:

a) manufacturer's clause-by-clause report;

b) third party clause-by-clause report;

c) demonstrated conformance to IEC 61508-3.

~~The manufacturer shall provide evidence that the software fully complies with 4.2.9.~~

The equipment shall be operated during the performance test in such a manner that, starting from the measuring state, it enters all special states.

The following operation states shall be performed if applicable:

a) four measured values distributed over the measuring range;

b) measuring range under- and overflow;

c) special states if they can be entered without destruction of the hardware or modification of the software;

d) activation of every message;

e) test routines if they can be tested without destruction of the hardware or modification of the software;

f) change of parameters.

Operation states a) and b) shall be performed for a selection of measuring ranges, including the minimum and maximum range.

5.4.24DV D2 *Addition of Clause 5.4.24DV as follows:*

5.4.24DV Environmental exposure

5.4.24DV.1 Dust

For equipment marked to indicate an environmental rating for protection against the ingress of dust, this test shall be performed within a dust chamber defined by ANSI/IEC 60529. The equipment shall be mounted in accordance with the manufacturer's instructions, set to the lowest alarm level or 10 % of the measuring range, whichever is greater, and then calibrated in accordance with 5.2.3, and the time to 90 % of the standard test gas application shall be recorded. No preconditioning of the equipment per 5.4.2, 5.4.12 and 5.4.13 is required. The equipment shall be exposed to the circulating dust cloud within the chamber for a period of 2 hours, -0/+5 minutes, with no vacuum applied to the sensor.